

7N-15-TM
190568

LAUNCH PAD TO THE MOON
CONSTRUCTION BIDDING COST OF LAUNCH COMPLEX 39
PART I

By

Joseph Andrew Brown
Aerospace Technician of Experimental Facilities & Equipment

National Aeronautics & Space Administration
Architectural & Structural Section
Kennedy Space Center, Florida 32899

Presented At

AMERICAN ASSOCIATION OF COST ENGINEERS
12th NATIONAL MEETING, HOUSTON, TEXAS
June 17-19, 1968

(NASA-TM-109269) LAUNCH PAD TO THE
MOON: CONSTRUCTION BIDDING COST OF
LAUNCH COMPLEX 39, PART I (NASA)
7 p

N94-70312

Unclass

29/15 0190568

LAUNCH PAD TO THE MOON
CONSTRUCTION BIDDING COSTS OF LC-39

Joseph A. Brown

This report discusses and summarizes the major construction contracts of Apollo Launch Complex 39 with methods, bid costs, and unit prices totaling over \$200,000,000. These separate contracts were for (1) design, (2) dredging and fill, (3) foundations, steel piles, and vibroflo tation, (4) structural steel, (5) general construction, (6) outfitting High Bay #2, (7) additional elevators, and (8) bridge cranes for the Vehicle Assembly Building, the world's largest building at the time of construction.

Other major facilities and machines of LC-39 are Launch Pads A, B, and Crawlerway, Mobile Service Structure, Crawler-Transporter, Industrial Water Supply, and Propellant System Components Laboratory. Some especially interesting construction methods used were critical path method of scheduling and payment, beam hanger suspended forming system eliminating 524 feet high shoring, four-story rail car cages for handling insulated siding, vibratory sonic hammers for steel piling, and helicopters for special lifting.

This is construction's answer to "The Big Challenge" an American on the moon by 1970.

PART I

LC-39, the nation's first operational spaceport ranks as one of history's greatest engineering achievements. It is located on Merritt Island--adjacent to Cape Kennedy (Canaveral). National Aeronautics & Space Administration (NASA) obtained congressional approval to create a national spaceport on 88,000 acres of Merritt Island in August 1961 and is known as the John F. Kennedy Space Center. KSC provides the launch facilities to support the space flight to the moon, exploration of the lunar surface, and a safe return of the astronauts. It is responsible for receiving, inspection, assembly, preflight testing of launch vehicles and spacecraft, and conducts launch of space vehicles.

While KSC developed design criteria for the spaceport, design and construction was carried out by various contractor organizations under the direction of the

Jacksonville and Canaveral District Office of the Army Corps of Engineers.

1. The Vehicle Assembly Building

(VAB) the world's largest building by volume at the time of construction, is where up to 4 Saturn V moon rockets and Apollo spacecraft can be assembled at the same time when the building is completely outfitted. So complex is the design that 4 New York architect engineering firms (Urbahn-Roberts-Seelye-Moran) combined to work on the plans under the joint name of URSAM, for \$3.3 million.

Max O. Urbahn-Planning and Architectural Work, Roberts and Schaefer Company Structural Work, Seelye, Stevenson Value and Knecht Mechanical Electrical, and Muesser, Rutledge, Wentworth and Johnston Foundation Engineers.

The space truss system of the VAB combines optimum stiffness with flexibility of layout with steel and concrete working together. The design provides for floors at the third point of the 38 foot modules--with 33 possible floors; however, only 27 floors are installed.

How big is big? (Vital Statistics)

It is 129,482,000 cubic feet--7 1/2 acres in area; (178,000,000 cubic feet with future expansion;) 525 feet 10 inches high x 715 feet 11 inches long and 516 feet 10 inches wide; imprint area of 343,500 square feet. Four doors on the High Bay are the largest ever placed on a building. 456 feet high x 152 feet at the bottom and 76 feet wide at the top. Over 10,000 tons of air conditioning capacity or enough for 3,000 average size homes and it is not completely air conditioned. Without climatic control it would be possible for clouds to form near the ceiling and for rain to fall inside the building. Construction time 1963 to 1965 - Awarded the Outstanding Civil Engineering Achievement of 1966 by ASCE.

2. Dredging and fill

Built on fill dredged from the Banana River - Access channel and hydraulic fill for VAB and LC-39 Pad A. Bid date - October 25, 1962. Government Estimate - \$3,835,300.

Bids \$3,618,500 \$3,770,243 \$4,224,000 High Bid \$4,498,730

Low bid by Gahagan Dredging Corp. Tampa, Florida

1. Mobilization and demobilization 1 job L. S.	\$ 135,500
2. Clearing and grubbing 600 acra @ \$585	351,000
3. Excavation Unclassified - Stripping 55,000 CY @ \$1.60	82,500
4. Excavation Unclassified at VAB and Mobile Launcher 1 and 2 335,000 CY @ .58	194,300
5. Excavation Unclassified Access Channel and Turn Basin 3,260,000 C.Y. @ .38	1,238,800
6. Excavation Unclassified Additional Borrow for VAB 1,010,000 C.Y. @ .36	363,600
7. Excavation Unclassified Access Channel and Basin Pad A 630,000 C.Y. @ .36	258,300
8. Excavation Unclassified Addition Borrow for Pad A 2,850,000 C.Y. @ .36	1,026,000
Total	\$3,618,500

3. Foundations

Foundations for VAB, LC-39

Bid Date July 2, 1963

Government Estimate \$12,045,639

Bids \$8,069,000 \$8,377,950 \$8,488,142 \$8,832,730
\$9,033,229 \$9,302,052 & \$10,514,775

Low Bid by Blount Brothers Corporation, Montgomery, Alabama

1. All work complete except the items listed below 1 Job L.S.	\$2,526,335
2. Steel Pipe Piles (16") 674,000 L.F. @ \$7.50	5,055,750
3. Portland Cement 49,800 Barrels @ \$3.75	186,750
4. Vibrofloation 37,700 L.F. @ \$4.75	179,075
5. Construction Roads	
a. Unclassified Excavation 26,000 C.Y. @ \$1.00	26,000
b. Stabilization 29,300 S.Y. @ \$1.30	38,090
c. Drainage 1 Job L.S.	7,000
Total	\$8,069,000

Approximately 4,255 steel pipe filling driven 150-170 feet - (ave 158') to bed rock; approximately 30,000 C.Y. of concrete pile cap and 1st floor slab. (\$84.21/C.Y. plus Portland cement).

4. Structural Steel

Furnish and erect structural steel for VAB.

Bid Date July 2, 1963

Government Estimate - \$30,459,526

Bids \$23,534,300 \$24,340,150 \$25,344,600 and \$30,609,000

Low Bid by United States Steel Corporation - Atlanta, Georgia

- | | | |
|----|--|--------------|
| 1. | Structural Steel for VAB loaded on carrier at shipping point, destination construction site 1 Job L.S. | \$17,811,300 |
| 2. | Transportation and Erection of structural steel for VAB at destination and all remaining work 1 job L.S. | 5,723,000 |
| | Total | \$23,534,300 |

Based on estimated 57,000 tons of structural steel.
And Low Bid

Item 1	Unit Cost per ton is	\$312.48
Item 2	Unit Cost per ton is	<u>100.40</u>
Total	Unit Cost per ton is	\$412.88

Note Bidder #2 Bethlehem Steel

Item 1	Unit Cost per ton	\$271.88
Item 2	Unit Cost per ton	<u>155.14</u>
Total	Unit Cost per ton	\$427.02

5. General Construction - Joint Venture

Vehicle Assembly Building (VAB), Support Utilities and Mobile Launcher Erection Area #3.

Bid Date January 7, 1964.

Government Estimate - \$61,260,531

Bids \$63,366,378 \$69,266,000 \$69,480,000 and \$74,343,696

Low Bid by Morrison-Knudsen Company, Inc. Perini Corp., and Paul Hardeman Inc.
A joint venture (M.K.P.H.) South Gate, California.

Unit Price Schedule

1.	VAB	Job 1	LS	\$44,451,733
2.	Launch Control Center	Job 1	LS	7,000,000
3.	Utility Annex & Assoc. Fac.	Job 1	LS	3,500,000
4.	High Pressure Gas Storage Bld.	Job 1	LS	100,000
5.	POL Paint & Chemical Storage Bld.	Job 1	LS	45,000
6.	Gate House	2 each		6,000
7.	Exterior Water Supply System			
	a. Exterior Water Line (18")		LS	300,000
	b. 250,000 Gal. Elevated Water Tank		LS	65,000
	c. 1,000,000 Gal. Ground Storage Reservoir		LS	70,000
8.	Exterior Sanitary System			
	a. Sewage Treatment Plant (108,000 gpd)		LS	125,000
	b. Sewage Lift Station		LS	15,000
	c. Exterior Sewage Line		LS	40,000

9.	Drainage Structure	LS	\$ 150,000
10.	Exterior High Pressure Gas Lines	LS	80,000
11.	Ext. Electrical Distribution System	LS	1,600,000
12.	Ext. Lighting System	LS	126,000
13.	Ext. Electrical Grounding System	LS	63,000
14.	Mobile Launcher Erection Area #3	LS	300,000
15.	Grassing Operation	LS	175,000
16.	Fencing	LS	25,000
17.	Crawler Road Tunnel	LS	90,000
18.	Railroad Grade Crossings 2 each		1,000
19.	Concrete Walks	LS	4,000
20.	Traffic Stripes & Signs	LS	4,000
21.	Unclassified Excavation 700,000 CY @ .60		420,000
22.	Proof Rolling 1,064,000 SY @ .02		21,280
23.	Graded Crushed-Aggregate Base Course 93,900 SY @ \$11.50		1,079,850
24.	Stabilization 15,210 CY @ \$4.00		60,840
25.	Limerock Base Course		
	a. 6 inch 18,200 SY @ \$1.25		22,750
	b. 5 inch 86,600 SY @ \$1.00		86,600
26.	Bituminous Prime Coat 46,500 Gal. @.30		13,950
27.	Bituminous Tack Coat 19,500 Gal. @.25		4,875
28.	Bituminous Concrete 16,100 tons @ \$10.00		161,000
29.	Sand Bituminous Ditch Pavement 3,800 CY @ \$2.50		9,500
30.	Allowance for Service & Maintenance Manuals Per Par. SC53 of Part II Special Conditions LS		100,000
31.	Allowance for Instruction Services Per Par. SC54 Part II Spec. Conditions 2,000 man days @\$100		200,000
32.	Base Communication System	LS	1,700,000
33.	NASA Communication System	LS	1,150,000
Total Estimated Amount			<u>\$63,366,378</u>

VAB Bid Cost per cubic foot = $\frac{44,451,733}{129,482,000} = .34$ for Architectural, Mechanical & Electrical

LCC Bid Cost per cubic foot = $\frac{7,000,000}{5,289,600} = \1.32

This bid includes 12 elevators to floor 34, 8000 # capacity 8' wide by 11' deep. And 1 elevator from floor 34 to roof.

Based on estimate s.f. of 1,500,000 and bid cost of \$44,451,733 = \$29.64/sf plus structural steel, and site work etc. This was for the architecture, mechanical, and electrical, including outfitting 2 bays with extensible platforms.

There were a great many especially interesting methods used in the construction of the VAB. Here are a few:

1. The system of forming the suspended concrete slabs - one would have required 524' high shoring, but a beam hangersystem was considered the most economical. However, a controversial problem was the extra deflection caused by the form work and the live load while pouring the slab.
2. The 4 story high rail cars or cages used to install the insulated metal siding - 1,085,500 sf 23 acres and 70,000 sf of light emitting plastic panels.
3. The use of helicopter to lift special equipment to go on the roof and near the top.
4. An unusually large number of jib cranes used in structural steel, erection.

6. Outfit Assembly High Bay #2

Bid December 6, 1966

Government Estimate \$6,838,392

Bid \$6,592,295 \$6,938,000 \$7,087,000 \$7,112,000 \$7,262,000 and High Bid \$8,673,680.

Low Bid by Akwa-Downey of Milwaukee, Wisconsin.

This consisted of 10 extensible platforms, reinforcing structural steel columns to take added loads, architectural, mechanical, and electrical work in outfitting Towers A and B. The work consisted of new walls, floors, ceilings, heating, air conditioning, plumbing, fire protection, power, lighting, wiring, bonding, grounding, paging, communication, and miscellaneous to complete Bay No. 2.

Weight of the platforms, using load cells, prior to lifting into position complete with air conditioning, lighting, power, cable trays, and hand rails, etc. is as follows:

Platform A, North	342,000 pounds	South 380,400 pounds
Platform B, North	375,600 pounds	South 384,100 pounds
Platform C, North	363,500 pounds	South 382,100 pounds
Platform D, North	378,400 pounds	South 425,500 pounds
Platform E, North	289,300 pounds	South 290,300 pounds

Based on a weight of 3,611,200# and an approximate sub-bid price of \$3,000,000 the price per pound equals 83 cents.

Work platforms, each of the completed assembly areas in the High Bay in the VAB, contains 5 pairs of extensible work platforms which provides air conditioned areas for technicians to work on the Apollo-Saturn V Launch Vehicle.

These platforms 60 by 60 feet and one, two, and three-stories tall were assembled outside the VAB and then moved inside for erection and mounting. The platforms are supported by the frame work of the VAB and are both vertically and horizontally adjustable to encircle the launch vehicle at various elevations.

When the platforms surrounds the vehicle each side of each platform is cantilevered about 30' from the main building frame. The area within each platform is air conditioned and is served by flexible connections to the main utility systems in the building. The platforms are sealed around the vehicle with neoprene seals to prevent damage to the vehicle with neoprene seals to prevent damage to the vehicle's skin.

7. Cranes

The VAB contains more than 70 cranes and other lifting devices principal of these are two 250 ton capacity bridges cranes and one 175 ton capacity bridge crane.

Each of the 250 ton cranes serves two assembly areas in the High Bay or opposite sides of the transfer aisle. The cranes weigh 500 tons apiece, have a bridge span of 150 feet, and a hook height of 462 feet.

The 175 ton crane runs the length of the transfer aisle through the low and high bays. It has a hook height of 166 feet. Bid 19 September 1963 as supply contract and assigned to NASA 61.

	<u>Low Bid</u>	<u>2nd</u>	<u>3rd</u>
Colby Crane & Manufacturing Co., Seattle, Washington			
Bridge Cranes for VAB 175 ton 1 each	\$ 592,258	\$ 279,000	\$ 940,220

	<u>Low Bid</u>	<u>2nd</u>	<u>3rd</u>
	Colby Crane & Manufacturing Co., Seattle, Washington		
250 ton 2 each @ \$763,371	\$1,526,742	\$1,880,000	\$2,747,056
Instructions & Technical Service Allowance 600 man-days @\$100.	<u>60,000</u>	<u>60,000</u>	<u>60,000</u>
Total	\$2,179,000	\$2,819,000	\$3,747,276

In summary the construction bidding cost of the VAB and associated work is:

1. Design	\$ 3,300,000
2. Dredging & Fill	3,618,500
3. Foundation	8,019,000
4. Structural Steel	23,534,300
5. General Construction	63,366,378
6. High Bay No. 2	6,592,295
7. Bridge Cranes	2,179,000
8. Additional Elevators (3)	<u>1,129,000</u>
Total Cost	\$111,730,473

On November 9, 1967, the first of the Saturn V moon rockets was successfully launched and returned.